

The reACT₂ant

Late
summer
2006-
2007

Volume 14 Issue #3

Fall Already??

I know we had the longest summer ever, but somehow I still wasn't quite ready to come back to school. However, now that we're in the swing of things, life has improved. Every year reminds me that this batch of kids is different than all the others that came before and that means a new set of eyes to dazzle with my favorite demo or a new set of groans prompted by my favorite punny joke. Isn't it cool that teaching provides enough challenge and variety that we don't get too bored from year to year.

Speaking of years...this fall is an unusual one in several respects. Both the ACS and STAT are celebrating special anniversaries: it's the 20th anniversary of the National Chemistry Week celebration and the 50th anniversary of CAST. Make a point to include those events in your fall schedule. National Chemistry Week, in particular, provides an opportunity to extend and enrich beyond the usual curriculum and you can probably find an applicable TEK (say 3B, 3C, or 3D) to justify the diversion.

Another thing that sets this fall apart from the recent past is the revised school calendar. The majority of districts in Texas will be returning to fall exams after Winter Break in January. I can remember from back in the day how futile the learning the last week before break seemed to be, and yet, still necessary. So, I'd like to share a bunch of ideas on how that last week or so can involve some good hard-hitting Chemistry, but still provide the WOW factor that students will need that week in order to maintain their interest. The next issue of the newsletter will include activities I receive and I already have the first one—Ed Escudero's recipe for

silvering holiday ornaments. I also plan to include a puzzle I used to use with my students, and of course, some awesome chemistry carols. If you have any labs, activities, puzzles, or games that would be helpful additions to the collection, please email them to me by October 15th so I can compile them and get the newsletter into your mailbox around Thanksgiving. If you picked up the idea from someone else, be sure to include that reference information, if possible.

Also, please note that I'm seeking contributions from ACT₂ members who attended ChemEd. Please share your favorites with the rest of the membership—see P. 10 for more details.



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President's Corner



I didn't see as many of you guys at ChemEd as I had hoped but there were several Texans walking in the rain. There were no major problems as far as the individuals were concerned but if you looked behind the scenes you would have noticed Jane Smith with a frantic look on her face screaming "I need a computer in room 411 NOW!" However, a few days cruising around on the Gulf of Mexico has been known to remove many stress lines from her forehead.

September has returned and everyone is back in school. I hope you are having a great year. The

Treasurer's Report 8/1507

Starting Balance	\$9604.58
Income <i>(dues, ChemEd seed, interest, etc.)</i>	\$14793.41
Expenses <i>(CAST booth, ChemEd etc.)</i>	\$13216.11
Ending Balance	\$6181.88
Actinium Fund	\$3410.00

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legislature has done their work and now we are hearing from Chris Comer and TEA regarding House Bill 1031. Some of the facets of the bill include:

- The 2011 -12 freshmen will be the first group to have EOC tests as a graduation requirement.
- They must score a 60 on a test in order to have that score count toward the cumulative score.
- Students scoring below 70 will receive accelerated instruction. (a.k.a. EOC tutoring)
- The EOC assessment grade shall be 15% of the student's final grade for that course.
- TEA will release EOC assessment questions every 3 years.
- Prohibits schools from spending more than 10% of instructional year administering district - required (a.k.a. benchmark) tests.

Jane Gray has finally decided to retire; she is AWOL at Katy H. S. and nobody knows where she is hiding. (She's probably lounging in her PJ's at noon in her kitchen). Don't forget to book your rooms for CAST in Austin early because the party runs long and late at the capital. Roxie has three rooms booked for the chemistry strand on Friday, and Dr. Ken Lyle, from Duke University, is our luncheon speaker. Hope to see you in Austin and have a fabulous fall.

Dale Moore

Call for Nominations

The Board needs YOU...to nominate a colleague for the George R. Hague Award for Teaching Excellence. The award is traditionally presented at the ACT₂ luncheon at CAST and is designed to honor a chemistry teacher who has displayed excellence, in the classroom, in their own academic community and/or within the chemistry community as a whole. George Hague was an amazingly enthusiastic and creative teacher who fostered high standards for his students and the teachers he influenced through his many presentations. George's tagline was "Chem Is Try" which is what all of us should encourage in our classrooms every day. The TOY (teacher of the year) nomination form can be found on the ACT₂ website at <http://www.statweb.org/ACT2> and can be submitted online or mailed to Dale Moore. The nomination form is comprised of general resume information as well as what special contributions the individual has made to the chemistry profession and/or chemistry community.



Deadline for Nominations is October 15th

The Board is also looking for folks who would be interested in running for an office on the Executive Board for the 2008-2010 term. If you would like more information regarding responsibilities, time commitment, or you want to get your name in the hat, now, contact Roxie Allen.

Join the Science Teacher's Association of Texas in celebrating the 50th anniversary of CAST—the Conference for the Advancement of Science.

"Celebrate the Past—Imagine the Future"

Highlights of this year's CAST include:

- Workshop Sessions: 4 slots on Thurs., 4 slots on Fri., 4 slots on Sat.
- Field Trips: Over 70 field trips on Thurs., Fri., and Sat.
- Short Courses: Over 100 short courses on Fri., and Sat.
- Exhibits: Over 400 vendors and exhibitors will be open at the Austin Convention Center on Thursday (2pm-7pm), Friday (9am-5:30pm), Saturday (8am-12noon)

The exhibit opening will be a big FREE event with complimentary tasty appetizers and beverages – and of course a big birthday cake! A band from Austin, the Mother Truckers, will deliver authentic country music and blazing guitars. Come celebrate in Austin on Thursday, November 15, from 5:00-7:00 pm!

You can download a registration form and mail in your requests for ticketed events and payment or you can register online with early registration at \$105 per person ending on November 1st. Late registration will be \$135 per person. If you cannot attend the entire conference, you can come for one day – Saturday – for only \$50 per person (which does not include STAT membership). Hotel registration is online until October 8th, but room availability at conference rates is getting pretty slim. Visit <http://www.statweb.org/CASTAustin/> for online registrations and additional information as well as a complete workshop schedule.

ACT₂ will provide its usual presence with an active booth in the exhibit hall, strands of chemistry workshops and a luncheon full of fun on Saturday with an ACT₂ alum, Dr. Ken Lyle from Duke University. Following the luncheon we will be reviving our Share-a-Thon so plan on staying for that!

Here's how YOU, as an ACT₂ member, can make a difference:

- Buy an ACT₂ luncheon ticket when you register
- Contact Rhonda Alexander and offer to work the ACT₂ booth for an hour
- Bring a teaching tip, lab idea, activity to the Share-a-Thon. If it's on paper, bring 50 copies. This is a great avenue for you to begin to share your ideas—it's the way many of us began doing presentations because it's quick and relatively stress-free!

ACT₂ Presents...**FRIDAY, November 16**

Clipping Along: Modeling 2-D and 3-D Bonding Patterns

9:00 – 10:15 ACC-Level 3-Room 6A Diana Mason Carmen Fies

Ideas That Work in Teaching Chemistry

9:00 - 10:15 ACC-Level 3-Room 6B Barbara Schumann Eva Lou Apel

A Demo A Week Makes Science Class The Peak

12:30 – 1:15 ACC-Level 1-Ballroom B Vinay Dulip Jeanne O'Leary
Carlos Montalvo

Take Home Labs: Will It Float, Snowflakes and More!

2:00 – 3:15 ACC-Level 3-Room 6A Amiee Modic Jane Gray

What? You mean I'm teaching science?

2:00 - 3:15 ACC-Level 3-Room 6B Ken Lyle

How to Balance Your Equation, and Eat It, Too!

2:00 - 3:15 ACC-Level 2-Room ML10 Elizabeth Gregory Mary Ann Baker

Fun and Games in Chemistry

3:45 – 5:00 ACC-Level 3-Room 6B Jane Smith Claudia Wallace

SATURDAY, November 17

Second Semester Topics

9:00 – 10:15 ACC-Level 1-Room 3 Janet Dickinson

Supporting TAKS with Chemistry Lab Activities and Manipulatives

10:45 – 12:00 ACC-Level 1-Room 3 Heather Hattori Paula Robinson

ACT₂ Share-a-thon

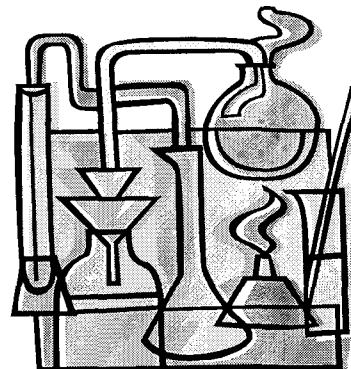
2:45 – 4:00 ACC Level 1 Ballroom C

ACT₂ Luncheon Speaker**Kenneth Lyle, PhD**

Lecture-Demonstrator

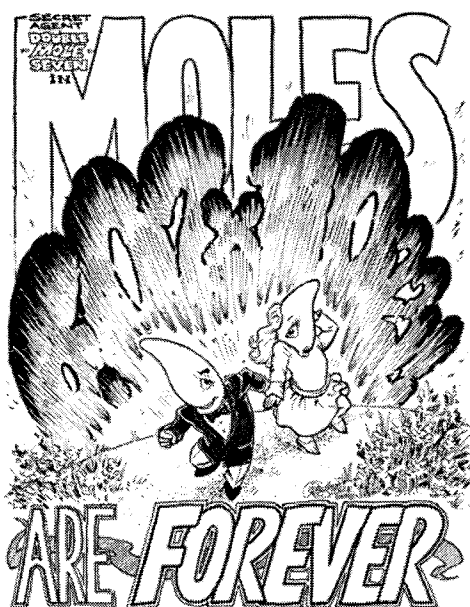
Department of Chemistry

Duke University

*Chemical Demonstrations:**A means to motivate students, foster understanding
of chemical concepts, and share the joy of doing chemistry*

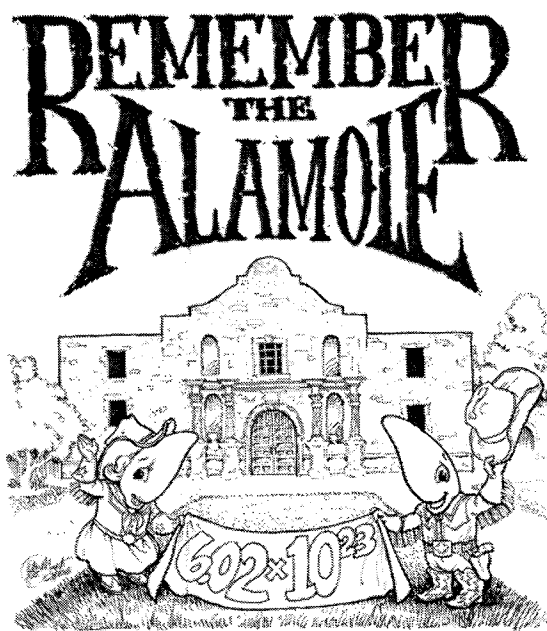
2007 is a very special Mole Day year because it's a *double feature*—that means that there are two themes and one of them was picked just for us Texans!

The National Mole Day Foundation website <http://www.moleday.org> has all the latest ideas for celebrating Mole Day. You can join the Foundation and they will send you a CD of this year's theme songs written by Michael Offutt as well as sample postcards, tattoos and lots of cool ideas. Their online store has t-shirts, pins, tattoos, postcards and more available for a reasonable price –but order soon, items tend to be quite popular.



Join Bond—Avogadro
Bond, on his molevelous
adventures.

Bowie, Crockett, Travis and
Houston have nothing on
Avogadro, Dalton and
Lavoisier!



I think Mole Day is a great opportunity to teach a little about what a mole is, even if you haven't actually gotten there yet in your curriculum. Have kids count out 100 black beans and 100 kidney beans (or two other types of beans very different in size) and then measure the mass of each sample. From there they can calculate the relative mass of kidney beans to black beans. They can also determine the mass of a million of each type of bean and determine that the relative mass stays the same. Have them take the next leap to calculate the mass of a mole of each type of bean. They can even compare that to the mass of the Earth to get an idea of how big Avogadro's numbers is and then show them several mole samples of elements so they can see just how small atoms are!

With all of the controversy over the revised Texas Pledge, let's raise some of our own. On Mole Day ask your kids to say one of these pledges as part of your class celebration. FYI—since you're pledging to the mole and you may not have one present, students can bend over and respectfully face the earth for the pledge!

I pledge allegiance to the mole, and to the science from which it comes, one *SI* unit, extremely divisible, with micromoles and millimoles for all. (Provided by R. Thomas Myers - Kent State U, Ohio)

I pledge allegiance to the mole, to the International Union of Pure and Applied Chemistry, and to the atomic mass for which it stands, one number, most divisible, with atoms and molecules for all. (Provided by Sylvia Cooper - retired, Morgantown, WV)

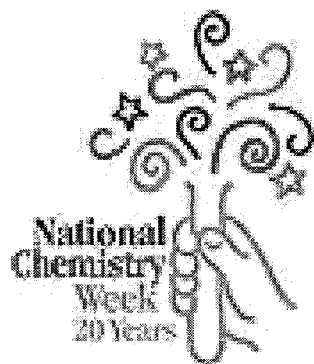
ACT₂'s own Rosendo Garcia from Connally High School in Pflugerville, Texas was crowned the 2007 Mole-of-the-Year at the Mole Day breakfast at Chem Ed. One of the definite highlights of the breakfast was seeing Rosendo's slide show of all of the places his world-traveling mole, George (in honor of George Hague), has visited.



George tries to call home—but doesn't have the proper pence!

George has visited 3 countries—England, Germany, Canada—and 13 states (Louisiana, Mississippi, Alabama, Oklahoma, Kansas, Missouri, Iowa, Indiana, Illinois, Wisconsin, Kentucky, Tennessee, Arkansas—oh, and Texas!). Rosendo plans to use some his award money to enjoy the next ChemEd and George is scheduled to visit the Antarctica this winter!

Want a copy of the patterns Rosendo's students use to make their moles? Check out http://www.statweb.org/ACT2/mole_patterns.htm



It's a special year for the American Chemical Society too—it's the 20th year of celebrating National Chemistry Week! This year's theme is intended to highlight chemistry in all its glory...

"The Many Faces of Chemistry"

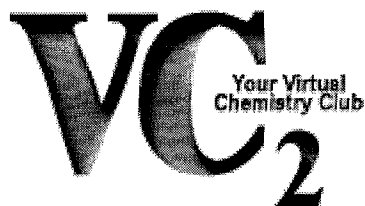
This year's theme promotes the diversity of the discipline rather than focusing on one specific field of or use for chemistry. You know, chemists aren't just the guys and girls in white lab coats with pocket protectors – they're also nutritionists, inventors, teachers, artists, detectives, and so many, many more. They solve crimes, clean our water, make us healthier and more beautiful, improve the materials we use and touch every aspect of our lives.

You can certainly find many more ideas for celebrating National Chemistry Week at the American Chemical Society's website <http://www.chemistry.org/NCW>, but here are a few to get you started:

- ✦ Conduct a department-wide, campus-wide or district-wide contest to see which office, work group, or school can most creatively assemble a periodic table – like a periodic table of cupcakes! If you don't want to go a full 3D, you could have your classes organize and collect pictures and clip art to make a periodic table collage.
- ✦ Seek out those sections in your chemistry book on chemistry careers, chemistry in the news, everyday chemistry and such that you never seem to have time for. Have students pick one to read and then have them do some quick research on another application of chemistry that relates to a hobby or interest of their own. Give each student a 1/2 sheet of colored paper and have them write a short paragraph highlighting what they discovered along with a picture. Post all of the cards on butcher paper and put it up in the hall so everyone can learn something new about chemistry!
- ✦ Find a fun activity from this year's or a previous year's issue of *Celebrating Chemistry* and share it with your family or grandkids or youth group or neighborhood. Get a group of your students to hold a science night event at a feeder elementary or perhaps for a local scout troop and do cool chemistry activities.
- ✦ Invite a guest speaker (not a stereotypical "chemist") to your classes from a local company to talk about how chemistry contributes to what they do.

The folks at Terrific Science Press (thanks Mickey!) have once again posted lots of great FREE ideas on celebrating National Chemistry Week. If you visit <http://terrificscience.org/ncw/2007/index.jsp> you can choose from a variety of topics that illustrate what chemists do in various fields like:

What Do Chemists Do?



Interested in the chemistry of Cheese Whiz, licorice or new car smell? Ever wondered exactly what a forensic or pulp/paper chemist does? Want to read up on some interesting chemical mysteries? Well, if you haven't been to the American Chemical Society's Virtual Chemistry Club site yet, you need to do it! Go to <http://www.chemistry.org> and from the Quick Links drop down menu, choose VC2. From there you can access links for What's That Stuff, Chemistry Mysteries, Careers in Chemistry, It's Elemental (a periodic table with essays for each element) and more!

You can also great some great ideas for chemistry's impact on our lives at the American Chemistry's Council website <http://www.americanchemistry.com>. They include information on: safety, health, environment, economy, innovation and everyday examples and their **essential₂ Public Information Campaign** section has some interesting resources which includes their public information advertisements which you've probably seen in print or on TV. Their home page says "Chemistry is bicycle helmets, medical supplies, fire extinguishers and clean water. We make the products that help keep you safe and healthy and create a brighter future for you and your family."

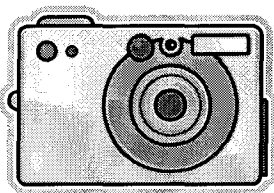
Do your part in October and put a real human face on the great field of Chemistry!!

Well, August 2nd allowed many of us to breathe a sigh of relief as we tiredly drove home to our loved ones. That's right, after years of planning, ChemEd 07: Lone Star Solutions had come and gone. Our lives were ours once again without hoards of emails requiring responses, bags of goodies to be stuffed, chemicals to be mixed and delivered, buses to be loaded or unloaded, certificates to be printed and the latest technical hitch in need of a solution.

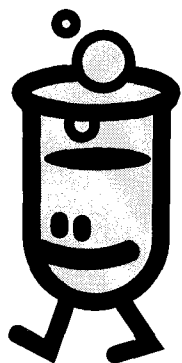
Some of my favorite highlights included watching people being attacked at the registration table to determine if they had a new card to trade and observing the armadillo butt blowing—I really don't think the pictures do it justice. We Texans kept trying to reassure the "foreigners" that this was an abnormally nice summer, weather-wise, but I'm not sure many were convinced.

Unfortunately, because I was running hither and yon, I didn't get to attend very many workshop sessions, but I would like to have some ChemEd highlights in each newsletter for the rest of the year for the folks who didn't have the chance to attend. **I NEED YOUR HELP!** If you went to a session that really whet your fancy, type up a short paragraph that summarizes what you saw and enjoyed and email it to me (act2smith@mindspring.com). Be sure to include the presenter's name and workshop title so I can give them appropriate credit. I have provided an example so you can sort of see what I mean:

Save That Lab! How to Turn Marginal Labs into Great Labs *Susan Klemmer*
Susan's session was very thought-provoking. She pointed out the dilemma many of us face—labs that we like for one reason or another, but dislike as well. Rather than just tossing out the lab completely, she suggests you think about what you really like and dislike and then use that to redesign it. For example, often "boring" labs can be made more exciting by having the students write their own procedure or adjusting it so that every lab group has a different sample to work with. If the lab is too confusing, simplify it or really focus on your pre- and post-lab sessions. If you decide it's pointless to do, but you like the chemistry—turn it into a test question or change the materials. She does a cool lab where students determine the % copper in brass by dissolving shavings (begged from a keymaker) and a spectroscopic analysis of the resulting solution containing a mixture of ions and blue-colored copper ions.



If you'd like to check out the shared photos from ChemEd, go to www.flickr.com. If you're not a member of Yahoo or Flickr already, you'll need to create a Yahoo (www.yahoo.com) account and then use that same info to sign into Flickr. Once you're in, use the search function to find the ChemEd group. Interestingly enough, you'll not only be able to view all of the shared pictures, but also some delightful shots of some girls group on a trip of their own! There are lots of good shots of fun and frivolity and some from the Comanche Peak field trip that you might be able to incorporate into your nuclear chemistry unit. It's not too late to add your photos—follow the directions for a public upload and then select and sent it to the ChemEd group.



From the AP List Serve—the strong acids cheer!

HiBer HiCkle HI, HoNO HiCkle-O, H-2-S-O-4!

(HBr HCl HI HNO₃ HClO₄ H₂SO₄)

These word puzzles appeared in the November 2002 edition of *CHEM13 news*.
Submitted by Gordon T. Walsh, see if you can guess the element shown.

Example: UALUMM

ALUM in (between) UM = ALUMINUM

(1) SC IUM

(2) UPLTM

(3) b/on

(4) STR
TIUM

Here's an interesting twist on the ol' research a scientist project...Smell Like a Scientist...a cologne name, ingredients and an advertising slogan that suits that scientist.

Isaac Newton's *Gravitas*

Ingredients: fresh-cut grass, royal mint, and, of course, apple spice

Slogan: For the man who likes his heavenly bodies as far away as possible.

Stephen Hawking's *Universe*

Ingredients: everything

Slogan: You don't have to understand it.

Socrates' *Philosophy*

Ingredients: olive oil, feta cheese, traces of hemlock

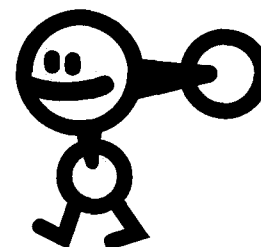
Slogan: You fill me with...questions.

Antoine Lavoisier's *Chemistry*

Ingredients: hydrogen and oxygen

Slogan: When the elements come together, you may lose your head.

These were collected by M.D. Rosenberg and published in *Funny Times*,
January 2007, page 5.



In lieu of this edition's elemental enlightenment, Dr. Marshall has graciously allowed me to reproduce (in a very edited form) his latest publication from Spring 2007 volume of *The Hexagon*, of Alpha Chi Sigma. I hope you'll enjoy his elemental journey on these "weighty matters" as much as I did.

In Sir Isaac Newton's *Principia*, physics had come to maturity: with the law of gravity and three laws of motion, the heavens with their celestial motions were no longer so capricious and future events could be predicted. With chemistry, the underlying forces and structure were more mysterious; understanding had to await the atomic theory of John Dalton in 1808 and the subsequent general acceptance by the scientific community, which did not occur for another half century.

In an early attempt to raise the level of sophistication of chemistry, Etienne Francois Geoffrey constructed a "Table of Affinities" using the concept of affinity from Georg Ernst Stahl who believed a relative ordering of "affinities" (the order in which substances displaced each other from compounds) would allow the prediction of other chemical reaction outcomes. Even after a century of use by 18th century chemists, the Table of Affinities did not lead to any enlightenment of the nature of chemical reactions, and clearly a new direction was needed. Instead, the way for understanding was provided by the idea of atomism, conceived shortly after the demise of phlogiston. John Dalton, who was color-blind, viewed his atoms as miniscule achromatic, featureless spheres, and he constructed models to illustrate his interpretation of atoms. He believed elements of a kind differed from others only by their weight.

The hypothesis that all atoms of an element had the same weight – the "atomic weight" – was based on Dalton's observation that constant ratios of elements combined to form compounds. Dalton's theories launched a century-long struggle of chemists to comprehend and even to accept atoms, until the discoveries of Ernest Rutherford in the early 20th century proved beyond doubt that they did exist. A glimpse into this debate is given to us by Thomas Thomson, who

describes a discussion which took place in 1807 at the Crown and Anchor tavern in London. At this meeting, Thomson and William Hyde Wollaston were trying to persuade Sir Humphrey Davy of the logicity of atoms. Once convinced, Davy became an ardent atomist; the Royal Society followed, and Great Britain was secured as a haven for the new theory.

Once it was recognized that compounds had constant compositions and that each element had its own "weight," research commenced to determine the atomic weights for all elements. But soon more questions were raised than answered. Although Dalton had assumed binary compounds combined one atom of each, this was by no means an established fact, nor was it generally accepted. While Dalton assumed HO for water (leading to an atomic weight of O = 8), Davy preferred H₂O (O = 16). There were interpretations regarding the term "atomic weight" and difficulties because the magnitude of the values depended upon the formula that one assumed for a compound. Inconsistencies abounded, and naturally, atomic weights derived by various researchers were generally multiples of each. For example, (on a basis of H = 1), O was given 8 or 16; N was given 7, 14, or 28. When one published a paper utilizing atomic weights, it was common practice to preface the article with one's own adopted set of weights!

A real impediment to the correct understanding of atomic weight was the commonplace belief that like atoms could not combine with one another. This was the logical conclusion ensuing from electrolysis experiments of metals, historically credited to Davy but, in fact, pioneered by Jons Jakob Berzelius. Berzelius was the first to conceptualize ionic bonding and he assumed this bonding occurred in all compounds. The idea that hydrogen was H₂ and chlorine was

Cl_2 never occurred to him, and his ideas held sway through the first half of the 19th century.

One of the first to understand “like” bonding was Jean Baptiste Andre Dumas who was asked to explore the reason why the burning candles in the Tuileries Palace were emitting obnoxious odors. He found that these candles had been bleached by chlorine and that the irritating stench was hydrogen chloride. His curiosity piqued, he followed up with much research that allowed him to conclude that either H (positive-like) or Cl (negative-like) could combine with carbon in a similar way and today we recognize that as covalent bonding. Dumas is best known today for his method of molecular weight determination. He developed this method in an attempt to understand molecular weights. His research indicated that an element may have more than one atom in its natural aggregate, but he was confused by some molecules that were “behaving anomalously” such as arsenic, phosphorus, and sulfur, which we know today are variable in their multiatomic formulas.

Friedrich August Kekule von Stradonitz, the famed discoverer of benzene, in 1860 proposed a convention to promote common understanding and eliminate confusion among chemists. A general invitation was issued for an international meeting of chemists to be held in Karlsruhe on 3 September, 1860 in hopes of reaching a “common agreement” on the definition of important chemical notions, such as those expressed by the words atom, molecule, equivalent, atomic, basic; the examination of the question of equivalents and of chemical formulae; and the institution of a notation and of a uniform nomenclature. After three days, the discussion had yielded some proposed compromises, but nothing seemed to satisfy anyone. Then an amazing thing happened: Stanislaw Cannizzaro, a charismatic speaker, distributed a pamphlet that stopped everyone in his tracks. The pamphlet showed how the forgotten and long-ignored work of Gay-Lussac, Avogadro and Dulong could make sense of everything.

Gay-Lussac’s work on determining the oxygen content of the atmosphere at different altitudes led him to the understanding of the respective amounts of hydrogen and oxygen that combined and led to the accurate determination that two volumes of hydrogen combined with one volume of oxygen. Claude Louis Berthollet was bothered by this because the reaction did not produce only one volume of water, but instead two and he reasoned “If the theory of atoms is true, how can $\text{H} + \text{H} + \text{O}$ give $\text{HOH} + \text{HOH}$?” Meanwhile Amedeo Avogadro was not so bashful about making atomist conclusions. He proposed in 1811 that the observations of Gay-Lussac were explained simply by the hypothesis that equal volumes of gases (at the same temperature and pressure) contained equal numbers of molecules. Although Avogadro’s hypothesis was far ahead of its time, because it could not be experimentally verified, it was generally ignored in scientific publications. It is additionally frustrating to realize that there was not only Avogadro’s research on gases that pointed the correct way, but there was also important information on solids thanks to Pierre Louis Dulong. His research showed that the heat capacity varied inversely with the atomic weight of an element was not taken seriously at the time because to establish this relationship, he had to change several of the established atomic weights.

Ultimately, Cannizzaro took up each element in turn, through the nonmetals, and the metals; always reassigning atomic weights where necessary on the basis of Avogadro’s hypothesis and Dulong-Petit’s law and showing that there were no ambiguities whatsoever. The audience was convinced. Two attendees, Lothar Meyer and Dmitri Ivanovich Mendeleev returned home to rewrite their lecture notes incorporating all of the changes required by the new atomic weights. Both realized that, in fact, new textbooks must be written incorporating the new chemistry...

Based on a document by Helen Stone



If the decimal point is present, start on the Pacific side at the first nonzero digit and count it and all the digits to the right of it. LEFT to RIGHT

If the decimal point is absent, start on the Atlantic side at the first nonzero digit and count it and all the digits to the left of it. RIGHT to LEFT

Examples:

15000	decimal point is absent, start at the Atlantic side at first nonzero digit and count to left, 2 significant figures the 1 and the 5.
2030.0	decimal point is present, start at the Pacific side at the first nonzero digit (number) and count to the right, 5 significant figures.
0.0020	decimal point is present, start at the Pacific side at the first nonzero digit (number) and count to the right, 2 significant figures.
2.000×10^3	decimal point is present, start at the Pacific side at the first nonzero digit (number) and count to the right, 4 significant figures. Don't count the $\times 10^3$.

Addition and Subtraction: The calculated value can only be as precise as the measurement taken by the least precise instrument. This is judged by evaluating the least common place value to all the numbers added or subtracted.

$$\begin{array}{r} 1.111 \\ + 20.91 \\ \hline 22.021 \\ 22.02 \end{array}$$

$$\begin{array}{r} 30.956 \\ - 5.3 \\ \hline 25.656 \\ 25.7 \end{array}$$

$$\begin{array}{r} 25 \\ + 42.789 \\ \hline 67.789 \\ 68 \end{array}$$

Multiplication and Division: Answers have only as many significant digits as the number that has the least number of significant digits. There is no attention paid to decimal places, just the number of significant digits. Ex. $4.51 \times 2.2 = 9.9$ is correct not 9.922.

Rounding: If the leftmost eliminated digit is less than 5, do not change the preceding digit. Ex. 2.414 rounds to 2.41. If the leftmost eliminated digit is 5 or greater, add 1 to the preceding digit. Ex. 0.5256 rounds to 0.526.

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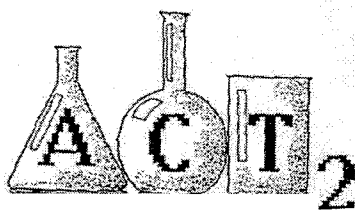
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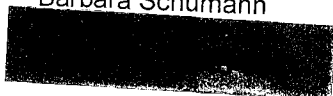
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